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Probing Artistic Process: A Progress Report from Harvard Project Zero

DAVID PERKINS

The first meeting of the term, the poet enters the classroom. He regards his students, each reaching for initial impressions. He delivers his opening message. "I cannot teach you how to write poetry. This course can ensure you'll have some time to write; we all can be an audience on which you can try your works; we can attempt some exercises which may be helpful. But I can't teach you how to write."

However discouraging his message, the poet's humility is understandable. He is not voicing the hoary misgiving of educators, that "you can teach 'em, but you can't learn 'em; they have to learn for themselves." He is justifiably awed by what he might be expected to do, to elicit genuinely creative products. No one else teaching a beginning course is routinely asked this. The "Physics I" instructor must convey a body of knowledge and skill in solving certain problems, not produce an insightful scientist. The historian's initial effort is to deliver and enliven a certain perspective on history; he need not engage his students in effective historical research.

This poet and many of his compatriots in the teaching of the visual, musical, and other arts are acutely aware that there is practically no general and communicable "hard knowledge" about skillful aesthetic endeavor. Conscious that they are professional practitioners, they are also conscious that even they themselves know remarkably little about the "how" of their effectiveness. (The scientific disciplines are really little better off here; but for many reasons science education can more easily avoid confronting the problem.) One resolution is for each to

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offer himself as a critic, a model, a goad, and an inspiration, admitting and even luxuriating a bit in the supposed ineffability of authentic creative effort. The other and complementary resolution is discovery of the missing information. Though certainly any detailed analysis of human excellence is a challenging and finally endless endeavor, if the questions are only confronted — which they rarely are — much progress should ensue.

Harvard Project Zero is a collaboration of individuals committed to this approach. Founded by the noted epistemologist Nelson Goodman in the fall of 1967 at the Harvard Graduate School of Education, the Project has sought to clarify the skills and abilities, the perceptual and cognitive processes underlying the comprehension and production of art. An early product established a foundation: Goodman's book *Languages of Art*¹ developed a taxonomy of "symbol systems" in the arts and sciences, accommodating scores, paintings, speech, print, graphs, diagrams, and more, and suggesting that differing types of symbol systems might demand particular symbol-processing skills. Publications by other Project members have ranged widely across individual interests and specialties, including studies of picture perception, style recognition, brain function, symbolic reference in music, on rhythm, children's development of musical skills, apparent motion, reading and pattern recognition, the lecture-performance as a technique to reveal artist's working procedures, of teaching methods in alternative schools, and on metaphor.² There have also been larger-scale monographs which have drawn on findings of the Project: *The Arts and Human Development* by Howard Gardner, *Images and Information* by John Kennedy, *Aspects of Motion Perception* by Paul Kolars.³

The aim of these pages is to provide some perspective on Project Zero's recent work, updating earlier accounts which have appeared in the *Journal of Aesthetic Education* and elsewhere.⁴ The variety of our efforts evidenced above — we are more a guerrilla band than a Roman phalanx — forbids an easy summary in a few pages, though longer accounts are available.⁵ The strategy here will be to offer a selective sampling of several Project members' recent research, a sampling designed to highlight a particular approach and to complement other studies developing more directly from *Languages of Art*, summarized in another general article.⁶

A prominent thrust in recent psychological investigation has been process analysis of human problem-solving. Rather than focusing on the aptness or failings of "output" from yes or no answers to term

papers, this approach examines in detail how the organism arrives at its output. Newell and Simon have traced reasoning processes in chess playing, theorem proving, and "cryptarithmic" tasks;⁷ Bruner, Goodnow, and Austin have probed concept formation;⁸ Piaget has explored the systems of thought underlying children's superficially unsystematic and simply "wrong" responses to various tasks.⁹ The emphasis on process has sometimes crystallized in educational efforts. A "productive thinking program" devised by Covington and Crutchfield has seen considerable use.¹⁰ The "Logo" project at MIT is a concentrated effort to teach children to think effectively on mathematical subjects.¹¹ Torrance tabulated 142 training experiments in creative problem-solving, most with positive findings.¹²

Whatever inroads this analytical approach has made on the mysteries of scientifically flavored thinking, the approach has seen little application in the arts or art education. Instructional methods typically emphasized include instructor and peer evaluation of works, supplying interesting subject matter and forms, exercises in particular subskills such as drawing the human figure, and providing verbal knowledge of the field. But what happens from the time a student picks up his pencil until he produces a draft for inspection is rather persistently ignored.

Recent investigations conducted by members of Project Zero have moved toward filling this vacuum.¹³ A review of these studies will be the main business of the following pages. Despite the common emphasis on process, the approaches vary. The behavior discussed ranges from that of the infant to that of the trained artist; music, literature, and the visual arts are considered. But taken together, the studies do speak to many general features of aesthetic thinking. Two of these discussed at the end will be 1) the use of oneself as a model of one's audience, and 2) fundamental obstructions to learning better procedures.

A SAMPLING OF STUDIES¹⁴

Deployment of Skills in a Poetry-Editing Task

Why students fail is a crucial question throughout educational practice. Conventional approaches look for an explanation in motivational factors, basic scales of ability such as IQ, the lack of appropriate educational methods, and so forth. Process analysis, in exposing the route by which the student arrives at his solution, asks what in particular did the subject *do* or *not do* that accounts for his success or failure. In these terms, one can ask what a subject's repertoire of "component skills" is — what discriminations can he make, what inferences can he

draw, what elements can he invent. On the other hand, there is another and often-ignored level of “managerial” skill: how does a student deploy his component skills for an assault on the problem at hand? An experiment of my own involving a poetry-editing task explored both these levels of capability.

Sixteen subjects — all of college age — were treated individually. Half were amateur poets; half were not. Each sought substitute words to improve underlined phrases in the last lines of five short poems. The poems were selected from obscure sources, and so chosen that the underlined words seemed to allow improvement. As each subject worked, he reported his thoughts aloud in a stream-of-consciousness fashion; his speech was tape recorded and transcribed for later analysis.

The solutions which subjects devised were on the whole unimpressive. Metric awkwardness, bizarre or downright incomprehensible meanings, or simply dull substitutions were commonplace. For one extreme example:

Without, there was a cold moon up,
Of Winter radiance sheer and thin;
The hollow halo it was in
Was like an “*ice filled yea empty cup*”

“improved” the original “*icy crystal cup*.” In all, perhaps ten out of fifty solutions offered could be considered to be as good as or better than the original materials, and subjects had the option of making no final choice. The reasons for subjects’ poor showings were sought through a close analysis of the transcripts.

Such inquiry is only interesting if some obvious explanations are discounted. Perhaps the subjects were pressed for time or undermotivated. Perhaps “thinking aloud” interfered with their capabilities. First, there was no time limit involved; subjects paced themselves. Second, some performances were certainly much less motivated than others, as judged by cursory efforts, deliberate and conscious carelessness, and casual abandonment of search with no solution at hand. But this was taken into account in the transcript analyses, and the results below apply as much to the serious as to the casual efforts of subjects. Each subject made a serious effort on at least one of the poems. Finally, the evidence is against “thinking aloud” interfering with performance. In a similar process tracing study on poets, Patrick found no such effects¹⁵ (subjects’ works produced during the test were compared with their prior corpus); in some contexts talking aloud is known to enhance performance;¹⁶ in the present study, only one subject obviously exhibited

such difficulties, and several subjects reported that speaking aloud seemed to help them organize their thoughts.

What, then, did account for the subjects' problems? Subjects generally considered very few options before giving up or making a final choice — an average of only twelve. Perhaps the problem might be a basic lack of fluency in conceiving of possible solutions, an interpretation well-matched to much prior thinking on the nature of creative thought.¹⁷ Or perhaps subjects could not discriminate between good and bad options. But no such explanations applied. Six of the original subjects returned months later for a series of tests stressing fluent production and discrimination. They were required to list possible constraints a substitute word should satisfy, actual substitute words, and pros and cons assessing the appropriateness of substitutes given them. These subjects generated at least twice as many items as they had in analogous tasks occurring naturally in their original performances.

The effort was then made to trace subjects' generally poor performances to procedural weaknesses. One such lay in subjects' evaluations of their conceived substitutions. Subjects rarely reported more than two pros or cons for their final choice, and pros and cons dealt almost exclusively with appropriateness of meaning, though the final choices were commonly redundant, ametric, clichéd, or otherwise inadequate. In contrast, the retested subjects conceived both many and subtle pros and cons bearing on varied aspects of aptness. Subjects asked to reevaluate some of their own original choices were both discerning and critical. The inventor of the above "ice filled yea empty cup" remarked slyly that the choice was "a little rhetorically superabundant."

Subjects' explorations of areas of meaning exhibited another procedural weakness. Searching through near synonyms — gleaming, glowing, sparkling — subjects would rarely consider more than two or three words, even though more could readily be retrieved, as the retested subjects demonstrated. Such a shallow sampling is not an adequate exploration in poetry, where nuance of meaning, as well as meter and sound, are so important that nearly synonymous words can vary greatly in appropriateness.

For other measures as well, the contrast between the original and retest performances argued that, in general, difficulties were due not to the lack of necessary component skills, but to ineffective deployment of component skills in fact possessed. Perhaps the flow pattern of subjects' problem-solving efforts could be tuned or more radically revised

to promote more effective use of those skills. A brief experiment in this direction was undertaken with the six retest subjects. In addition to the fluency tests, each subject attempted to devise an improved substitution for a new poem, but following a procedure specified by the experimenter. Subjects were to first imagine as many constraints as they could that a solution should satisfy; then subjects were to select their favorites from these and, guided by those constraints, conceive as many substitutes as they could. Then subjects were to select their favorite substitutes and generate as many pros and cons as they could.

Performance using this scheme was markedly more effective. Subjects' final choices were better, and subjects conceived far more constraints and options with which to work. Though certainly such a relatively rigid procedure would not be optimal, the study demonstrated that a drastic revision in procedure could sidestep many problems of deployment and organization which subjects had encountered in their original efforts. On the other hand, subjects' evaluations of their options exhibited the same brevity and biases as originally. Acute and objective evaluation of one's own ongoing work emerged as a particularly stubborn barrier to effective performance.

Experiments with a Computer-Controlled Music Box

Even the nonpoets in the poetry-editing experiment arrived prepared to both understand and produce writing. A routine facility in understanding print, pictures, and music is acquired in our culture as a matter of course; for those with the interest, it provides the foundation for more sophisticated aesthetic encounters. But the same cannot be said of even routine productive skills. Writing is given extensive attention, the visual arts some attention, and the framing of musical statements practically none at all, with music training being limited almost entirely to performance and there to a relatively limited perspective: building a set of reflexes which will translate notes on the page into sounds. Uncomfortable with this situation and concerned to know how novices could deal with constructive musical tasks, Jeanne Bamberger has been conducting studies employing a computer-controlled music box.¹⁸

Among the methods she has devised is a game called "tune blocks." Engaging subjects in this game permits her to trace the problem-solving processes which they employ in assembling a tune, and to determine whether they can make certain musical discriminations. The mechanics are straightforward. The subject sits at a console essentially like a type-

writer. By typing a single label — “G3,” for instance — he commands the music box to immediately play a melodic fragment three or four notes long. By typing strings of labels — “G3 G2 G2 G5” — he invokes a longer melody, the concatenation of the fragments. The subject is given a small repertoire of fragments — typically derived by segmenting a familiar or unfamiliar tune — and asked to build a whole melody that he likes, that makes sense to him. Tape recordings of subjects’ remarks and tunes and the typed sheet from the console provide a record for later scrutiny.

Though Bamberger has analyzed a number of subject’s performances, reviewed here will be a comparison between two, Mark and Jorge, college students with no extensive musical training who both dealt with the same set of five fragments derived from an unfamiliar French folk tune. First, the final tunes which the subjects devised contrasted markedly in design. Mark’s was structured with balanced antecedent and consequent phrases. Jorge’s began by introducing a brief motif, passed on to material that developed this motif, and came to a climax followed immediately by a close. The contrast was probably due to differing cultural backgrounds. Mark sought the antecedent-consequent structure common to American nursery rhymes, and indeed, to the original French tune. Jorge, of Peruvian origin, devised a tune paralleling the structure of Peruvian folk songs.

The problem-solving procedures of the two also differed. Mark was by far the more methodical. Quickly choosing beginning and ending fragments, he incrementally extended these endpoints to achieve a smooth bridge between them. Jorge soon found an ending also, but dealt mostly with combinations two or three fragments long, exploring many such units and combining them in many ways. Jorge requested many more performances from the music box than did Mark, mentioning that he could not remember the fragments but had to hear them. In contrast, Mark was able to do much in his head.

Bamberger also noted contrasts in Mark’s and Jorge’s access to local and global features. Local features are characteristics of a fragment in isolation or in relation to another fragment: the number of beats, the time span of a fragment, two fragments having identical rhythms, or the like. Global features refer to the actual or possible function of a fragment within a piece: beginning or end, a downbeat, an upbeat, part of a harmonic progression. From the first, Mark took note of many local features and inferred how the pieces might be fitted together to form a coherent global structure. Jorge could judge whether the com-

binations he tried made sense to him, but not until very late did he begin to anticipate on the basis of local features what revisions in his whole tune might be effective.

Such analysis underscores the diagnostic value of “tune blocks” and similar games. They permit a unique insight into the tactics and skills, the blunders and weaknesses of individual subjects, as illustrated by the contrasting procedures of Mark and Jorge. Refined educational objectives are the consequence: particular problems at both the microscopic level of perceptual skills and rapid automatic inference and at the broader level of organized management of those skills can be individually addressed.

But the potential role of such games reaches well beyond diagnosis. “Tune blocks” give the subject neither whole melodies nor individual notes to work with, guarding against both easy repetition of an established piece and complete bewilderment in the face of countless note combinations. Rather, offering fragments of tunes leads subjects such as Mark and Jorge to confront musical structure and the relations between local properties and global functions. Not only the experimenter, but also Mark and Jorge are informed by their focused experience. The computer-controlled music box becomes not just an investigative means but a possible paradigm for building musical awareness.

Training Children to Discriminate Style

Bamberger’s basic strategy was to confront subjects with an unaccustomed task and see whether and how they could deal with it. How such genuinely new challenges might be met and managed is of course a crucial question; it gains even more importance when we realize that abilities and concepts which adults routinely exercise were once formidably strange.

An experiment in training children in style recognition is a case in point. In prior work, Howard Gardner has discovered that children tended to spontaneously group paintings by dominant figure or subject matter — putting horses with horses, people with people — and that most pre-adolescent children seemed entirely unaware of stylistic grouping possibilities, where Picassos would occupy one pile, Chagalls another, regardless of subject matter.¹⁹ The question remained whether they could be trained to discriminate along this unfamiliar dimension.

To test this, Gardner adopted a simple reinforcement design.²⁰ In weekly sessions over a six-week period, twelve seven-year-old and twelve ten-year-old subjects were presented individually with several

always different sets of four painting reproductions. The subjects were required to group each four into two pairs according to a "special way" that it was the subjects' job to discover. Subjects were simply told "Yes, that's right" or "No" in response to each pairing they proposed. The sets of four were so chosen that sorting by style — operationalized as pairing works by the same painter — led to different groupings than sorting by dominant figure, the natural tendency. Pre- and post-tests administering similar sorting tasks but without feedback from the experimenter demonstrated that most subjects, even at the younger age, could learn to sort by style.

Here, it is not the particular statistics of their success but the findings on the nature of the learning process which are germane. The experimenters supplemented the pre- and post-testing by noting subjects' intermediate performances and their comments on their own strategies. Analysis of these factors suggested an intriguing general picture of subjects' progress in dealing with the task. There was one initial and necessary step: a subject had to realize that grouping by figure was incorrect. The older subject group accepted this readily, and many quickly realized that style — a concept they seemed already familiar with — was the proper basis of grouping. But many of the subjects in the younger group were shocked and confused to discover that a figural grouping was incorrect. It should be noted that some subjects, learning to ignore figure, never learned to sort by style. Knowing what *not* to do was not a sufficient strategy for success, since there was a third non-style, non-figure way of pairing.

Subjects conceived a startling variety of grouping strategies, sometimes entertaining them but briefly, and sometimes persevering with them for long periods despite only accidental successes. The color of the paintings, their size, the sex of a portrayed figure, indoor versus outdoor scenes, dark versus light, empty versus full, familiar versus unfamiliar, good versus bad, were just some of the criteria mentioned by the subjects. Such hypotheses are a sharp reminder that (here as in other circumstances) simple "yes" or "no" feedback, like simple punishment or reward reinforcement, often encourages the formation and persistence of irrelevant strategies.²¹

Other subjects who did not immediately realize that stylistic features were relevant conceived partly successful hypotheses which might be called "solders" because of their partial correlation with the true criterion. "Family resemblance" was one common solder: a subject would ask himself whether people portrayed seem related, or more generally

whether, for instance, a portrayed person seemed at home in a country scene. Employing another solder, some subjects asked themselves whether alternative paintings would look comfortable in the same setting — a theater lobby, church, or bank. Such solders do not indicate an explicit awareness of textural and other surface features relevant to style, but they do seem to invoke covert attention to stylistically relevant features by casting the decision task in a context, such as family resemblance or setting, where style *would* be a relevant consideration.

These partly successful (and many more downright wrong) strategies contrast with other possible findings. Subjects might have learned to sort by style in an all or none fashion, either succeeding or not; indeed, some students who seemed already familiar with the concept of style did exhibit such an abrupt shift. Or again, the learning which took place might have been characterized as an incremental and subconscious weighting of style-relevant features and discounting of irrelevant features in response to reinforcement; here behavior would gradually and steadily converge toward good performance.

But subjects' performances and hypotheses argue that both these accounts are inadequate. On the contrary, Gardner's subjects performed essentially like subjects participating in a concept formation task,²² explicitly formulating and testing alternative hypotheses. The role of intelligent effort in building a kind of perceptual acuity is underscored. The way toward successful performance is seen as neither a cliff nor an even climb, but a construction of hazards, byways, and halfway houses which the learner must thoughtfully negotiate.

The Structure of Practice

If novel tasks call upon the full measure of an individual's conscious capacities, the opposite is not reliably so: routine tasks may require just as much focused and deliberate thoughtfulness. Practice in music is a prime example. Vernon Howard speaks to this issue not as an experimenter but as a philosopher and trained vocalist who has often exercised this valuable double perspective.²³ His approach points up the dependence of any analysis of the arts on the established body of lore and procedure: an understanding of the arts drawing only on those few aspects which have been subjected to formal experimentation would be spotty indeed. His viewpoint also warns us that a *mélange* of often contradictory principles and techniques, the ability of a few gifted instructors to nurture their students' talents without being able to explain how they manage this, the cross-currents of novelty and

tradition, fashion and fundamentals do not in themselves as phenomena constitute an orderly view of the arts. Rather, they are the data from a vast natural experiment. It is the philosopher's and aesthetician's task to overcome confusion and misconceptions and assemble a coherent picture from this scattered mosaic.

Howard's initial point is that practice is often misconceived as "mere repetition"; such a characterization captures nothing of the complex organization of sophisticated practice. First, a whole piece is not repeated over and over in its entirety: passages presenting special difficulty are excerpted for focused attention. Second, the notes in those passages may be altered to create an exercise tailored to the problem the performer is having. Third, when the passage itself is practiced, dimensions of nuance, expression, or tempo may be dropped or altered while the performer concentrates on that aspect which is causing difficulty. Fourth, when this highly abstracted passage is repeated, it is not *merely* repeated; the performer must maintain an alert awareness of each repetition, constantly striving to shift his delivery toward whatever goal of fluency, timbre, or expression he desires. Finally, the passage must be re-embedded in the piece, and dimensions which were ignored during practice must be restored.

These and similar highly organized procedures work to counter numerous factors actively impeding the development of a skilled performance. Among such are the effects of fatigue and tension on the standards one maintains for oneself; as these loom, standards inadvertently drop. Another threat is oversatisfaction with partial success. Very commonly a singer, having achieved a high C, will rush to incorporate it as the dramatic moment of every piece in his repertoire, neglecting timbre, expression, and the structure of pieces as a whole for the sake of that one display. Further, practice is a constant struggle against undesirable but entrenched habits. After one has attained considerable facility, a return to a piece learned earlier will often reinvoke old reflexes: one's new performance of the old piece is no better than it was originally. Counterproductive habits of posture and breath may persist if not explicitly eliminated. The choir boy who lifted his chin upward to achieve a high note may find himself years later doing the same reflexively as he continues his voice training, even though just the opposite posture is optimal.

As if these obstacles were not enough, problems of self-observation also confound effective practice. The singer is his own instrument and does not sound to himself as he does to others. Tape recordings and

the guidance of a coach can provide intermittent objectivity, but not the continuous monitoring which the singer needs during practice. One must learn the systematic correlations between the sounds he hears himself making and the sounds as they are heard by others. For instance, in the lower register, the manner of delivery that carries best may not be the manner that seems loudest to oneself. In addition, the performer must simultaneously execute his piece and monitor it. He cannot, like the painter, execute a stroke and then stand back to deliberately regard it.

From these considerations and his own experience, Howard argues that, for the performing arts in general, new pieces should tax the student moderately, rather than lying near the limits of his capabilities. There are simply too many variables to be controlled on a second-to-second basis for him to manage difficult works; a performance that demands all his resources for tone or pitch will force him to drop other considerations of structure or expression. His own practice will make habits of these lapses. This situation may contrast with the nonperforming arts, where, over a series of sessions and attending to one aspect at a time, a student could be encouraged to revise a work to the limits of his capabilities.

The Presymbolic State: Infants' First Encounters with Fingerprints

To this point, the studies reviewed have dealt with specifically artistic problems. But any artistic task draws on basic skills of symbol processing that are the common background of many other human endeavors. Project Zero has been as much concerned with this scaffolding which makes artistic effort possible as it has with those further reaches of refinement and specialization that characterize comprehension and creation in the arts *per se*. In this spirit, the following three studies will serve to place the earlier four in a larger frame.

The artist is a symbol maker, the critic a symbol interpreter *par excellence*. Their special talents can be viewed largely as especially developed skills of symbol processing. We have all been symbol users for so many years that we can easily forget the human organism does not begin that way. The first study considered probes a period of pre-symbolic behavior which can provide a baseline for the more sophisticated performances considered later.

John Kennedy, in collaboration with E. Mueller of Boston University and Harvard student J. Moscow, conducted an examination of infants' first encounters with fingerprints.²⁴ The two experimental ses-

sions involved five infants, one infant being different in the second session; ages ranged from thirteen to fifteen months in the first session, the second taking place two months later. The infants accustomed themselves to a small room and one another, after which the experimenter-supervisor applied fingerpaint in pools to the smooth paper covering a coffee table surface. No attempt was made to guide the infants' subsequent behavior, but videotape records provided for a later close analysis of their spontaneous activities over a number of minutes.

The infants revealed a consistent pattern of exploration. Proceeding at different rates, they approached the table, sometimes resting their hands on the unpainted surfaces but not in the paints. Next the tips of a few fingers contacted the paint, followed by small motions of the hand. The flat of the palm was then usually applied and cyclic motions explored. Bodily involvement progressed steadily from then on; movements became faster and larger; elbows, whole arms, or even feet and heads finally became involved. Thus the sequence unfolded from close observation to tiny, cautious movements with minimal contact to broader and less precisely controlled contact with a gradual waning of fine attention. The same sequence was repeated during the second session, though some infants progressed through it more rapidly.

Their behavior is best seen as a general strategy for exploring new materials and situations. The sequence of involvement from limited-controlled to extensive-uncontrolled seems only prudent in a world where a new substance could be a joy or a threat. The paints marking the paper might trigger some built-in motivational factors of man-the-symbol-maker, but in general the infants were obviously exploring the paints as a substance, not as a symbolic form. As far as the infant behavior looks forward to the mature artist, it does so not in a concern for symbolic meaning or expression but in its orientation toward exploration and exploitation of the physical characteristics of a medium through intimate physical contact.

Symbolic Acculturation: Understandable Picturing in Five to Seven-Year Olds

The acculturation of the presymbolic child means, perhaps above all else, the opening of many effective channels of communication. Communication in turn implies a sender and receiver of messages. An early and essential lesson is that the message must be tailored to the knowledge and interpretive powers of the recipient. The intriguing aspect of this problem is its persistent resurrection in new guises. Just as the child may have difficulty in conveying through a picture the simple

identity of an object because he does not match his picture to his audience, so can the mature artist unintentionally fall into patterns of idiosyncratic statement incomprehensible to his audience. A study by Diana Korzenik examined the nature of this crucial lesson in learning to picture.²⁵

The study focused on the procedures of 82 five, six, and seven-year-olds attempting a simple communication game. Each subject was given one of three words, "bridge," "sidewalk," or "jumping," and asked to draw a picture representing that word. After a subject had completed an initial drawing, he was invited to play the game. Another pupil would come and try to guess his word by looking at his picture. If he failed, the guesser would go away, and the subject could draw another picture to let the guesser try again; this cycle would continue as long as interest was sustained or until the guesser succeeded. Subjects' drawings were preserved, and speech was recorded and transcribed. In addition, during the experiment subjects were questioned on various attitudes they held.

The younger subjects experienced the most difficulty with the task, displaying a variety of inept strategies. Features noted verbally — the rungs of a ladder, for instance — would not be drawn at all. Meaningful gestures would accompany a quite ambiguous drawing — a child might jiggle up and down while drawing "jumping." In general, subjects' efforts to articulate a symbol sprawled outside the drawing into gestures and words. Other subjects proved aware of the need to provide adequate cues in the picture, but they reasoned badly about what cues would serve. A square shape bisected by a long horizontal line would signify "bridge" because the guesser "will see this book (the square) that dropped on the bridge when the car went over it; he'll know it's a bridge because there's a book on it." But some, mostly older subjects, made few or none of these errors, dealing effectively with the task.

Korzenik argues that the children's behavior reflected fundamental attitudes about three aspects of communication: the self, the medium, and the "others" — the recipients of the message. The premises underlying ineffective performance could be summarized as "What I (self) mean is always clear," "the medium always does just what it should," "others are stupid if they don't know what I mean." The effective performances reflected a more realistic world-view: "I have to explain myself to be understood," "the medium must be made to show what I mean," and "others can't know what I mean unless I help." These premises were not merely abstracted from subjects' nonverbal behavior;

questioning the children revealed that such attitudes were quite consciously held.

In Korzenik's view, this shift in children's premises, one phase of the general developmental trend away from egocentric and overcontextualized behavior, should not be dramatized as a tragedy. However charming the many ingenuous efforts of early childhood are, the child operating thus is not functioning with an awareness of the problems of communication. Though a mature artist may gain much from a delicate balance between highly personal images and comprehensible statement, or may even select personal statement at the expense of an audience, the child of five has no such choice. The shift from the first to the second set of premises is a major step toward dealing knowingly and flexibly with pictorial communication and art.

Routine Symbol Use: Error Detection through Meaning and Grammar in Reading

If the symbol maker learns to work for comprehensibility, no less does the symbol interpreter learn to work for comprehension. The layered meanings of a poem, the formal arrangements of representational painting, the structure of a serial composition are features we may need to labor to perceive. Such special efforts are built on an essential foundation, a routine facility with unchallenging symbolic materials—the daily newspaper, TV, the top 40. But whatever the illusion of effortlessness, the vigorous thrust to comprehend is as present here as in more demanding materials which may elicit a self-conscious effort. Several experiments on reading by Paul Kolers point up the continuous intervention of thoughtfulness into the most prosaic of symbol-processing activities.²⁶

Only one particularly telling study will be reviewed here. In this experiment, college students were required to read aloud "transformed text," normal English text that had been rotated, inverted, or geometrically transformed in other ways. Subjects' speech was tape recorded for later analysis. Subjects can read such text aloud, but haltingly and with many more errors than would ordinarily be made. By making an everyday task more difficult, Kolers exposed mechanisms of error detection and correction obscured by the near perfection of normal performance.

Subjects would commonly substitute another English word for the actual word that appeared in the text. Sometimes the substituted word would be visually similar to the correct word; for instance, "paid"

might be substituted for "said." On other occasions subjects would substitute words that bore no visual similarity to the words given in the text. First of all, Kolars asked whether a substitution error provided a grammatical and meaningful sentence up to the point of the error. He found that 99 percent of errors not involving visual similarity and 89 percent of those involving visual similarity did so. In other words, utterances that were errors in failing to match the printed text were *not* errors in failing to fit the message as so far processed.

Kolars then asked whether a substitution error yielded a meaningful and grammatical sentence as a whole, and also whether subjects corrected their errors. He found that for errors involving no visual similarity, 89 percent of the uncorrected but only 48 percent of the corrected errors yielded good sentences. For the cases of visual similarity, 61 percent of the uncorrected but only 19 percent of the corrected errors yielded good sentences. In other words, the mismatch between the substitution and the continued processing of the sentence alerted subjects to the error. Inversely, most mistakes yielding acceptable whole sentences were left entirely uncorrected.

The sum of these observations is that the reading process strives more to achieve semantic and syntactic sense than to match the printed text precisely. The difficulty of accurate proofreading is an everyday testimony to this same point. But if this normally facile and silent process is best characterized as an active quest rather than a passive reaction, surely our conception of more subtle interpretive acts served by that basic skill, such as the reading of literature or poetry, must move in that same direction.

Often an immediate and spontaneous response to a work of art is labelled as genuinely perceptive, in contrast with supposedly destructive puzzling over a work. But Kolars's study argues that facility simply conceals the same sort of puzzling-out processes which are sometimes labored and obtrusive. Certainly the facile response is the more pleasant; perhaps it is the more penetrating because of its facility. But to suppose that one can "start at the top" as a sensitive and immediate responder is to overlook a point: genuine facility is in part an internalized and routinized version of performance once very conscious. And to suppose that even the sophisticate should limit his response to immediate reactions is to miss another point: more demanding works, if they are fairly met, will overwhelm the reach of even his unconscious facilities, requiring again the utmost of conscious and deliberate attention.

THE SELF AS A MODEL OF THE AUDIENCE

Diverse though they are, the individual studies summarized above all bear on the roles of man as communicator and artist and illuminate some important themes common to symbol-making of all sorts. One of these themes is the use of the self — the maker of the message — as a model of the recipient of the message, as a model of one's audience. In Korzenik's study, the child is seen learning between the ages of five and seven that he must take into account what his audience is likely to know and understand. In Howard's examinations of practice in music, Bamberger's studies compiling tunes out of fragments, and my own work in editing of poetry, this strategy has become entrenched. Subjects continually alternate between close perceptual attention to their evolving product and efforts to modify that product in response to problems they perceive. Even in such rapid perceptual-cognitive processes as are examined in Kolers's study of reading, the human organism's persistent monitoring of its own output is exposed.

The advantages won by using the self as a model of one's audience are telling. The self is — or at least one hopes the self is — a refined and informed audience attuned to one's message and sympathetic to one's basic aims. The self is always there on short notice and is as ready to examine initial scribbles or a half-completed work as it is to ponder a nearly finished product. Such use of the self is the pragmatic answer to the perhaps impossible problem of explicitly codifying aesthetic principles. As long as the reactions of the self model sufficiently the reactions of the audience, the work underway can be guided toward effective communication, however covert the principles governing both reactions of self and audience may be.

But general experience, common sense, and a number of points raised in the above studies all argue that regardless of one's skill as an interpreter of messages, numerous forces confound measuring the meaningfulness of one's message through one's own interpretive powers. One of these factors is the mismatch between self and audience created by individual histories. This can be a question of cultural background and assimilated conventions — as in Bamberger's study, where the two subjects devised tunes apparently reflecting culture-bound schemata acquired in their youth. Even more baldly, aesthetic communication can easily falter through sheer mismatch of knowledge. An artist that draws his imagery from any special domain — science, mythology, history — restricts the range of people able to fully respond.

This is his choice to make, of course. One cannot bow continuously to the greatest possible number, and there is a compelling and fertile impulse to plumb personal areas of knowledge in search of a unique voice. The problem is one of *informed* choice. Some children in Korzenik's experiment presumed an accident of their personal experiences would be known to the "guesser"; on a more subtle plane anyone may easily presume that those to whom he wishes to speak are more informed than they are.

Lack of distance from a work underway is another confounding influence. However attuned to an individual's style any select audience may be, they do not know the odyssey of intentions, of options devised and rejected, of conflicts and resolutions, underlying a particular work. But the maker's assessment of his own ongoing effort is inevitably skewed by such awareness. Thus in the poetry-editing study, subjects would become so oriented to considerations of meaning during their search for options that their evaluations would overlook factors of sound play or meter. Again, subjects would propose a solution essentially incomprehensible to a reader, not realizing that its meaning was clear to them only because they had conceived it with a certain meaning in mind. Psychological problems aside, gross physical factors intrude in the performing arts: the dancer does not see himself dancing; the actor does not see himself acting. As Howard stressed, one's own voice does not sound to the self as it sounds to others.

The conventional solution to the distance problem is to set the work aside, returning to it after forgetfulness has cast one back to something approximating a naive response. In the performing arts, the physical problems of self-observation can be met through viewing tape recordings, videotapes, or films of one's own efforts. In both performing and nonperforming arts, the more objective viewpoints and insights of a friend or colleague, master or coach, may be sought. But, immensely useful as they can be, such strategies lose the primary advantage: the *immediate* use of the self as the audience, the instant availability of a critical reading which can guide the moment-to-moment evolution of the work or performance.

The alternative and complementary answer is to be sophisticated about observing one's own work. A role-playing attitude can be adopted. Personal reactions can be sifted suspiciously for bias. Correlations can be found between subjectively observable cues and the objectively apparent effects. And just as a proofreader may scan a text backward to catch typographical errors overlooked in the search

for meaning studied by Kolers, so can one regard one's own works perversely—backward, upside down, with meanings and forms in mind contrary to intent—to shuffle off funneled thinking for a new perspective. The lack of such sophistication appears to underlie a great many inept products.

Finally, the sheer desire to count oneself a success may lead to a dangerously indiscriminating self-as-audience. Howard has spoken of the singer who, having achieved a shaky high C, displays it in his every performance at the expense of other musical qualities. Paradoxically, some moments of blind satisfaction are probably essential encouragement for the novice who cannot be expected to accomplish everything at once, and who would simply be discouraged were he always to perceive accurately the level of his own effort. Most stimulating use of the self as audience may demand a delicate balance: maintaining fussiness just at the limits of productive capacities.

The lesson of all this is that the youngsters moving from Kennedy's presymbolic encounters with materials through the simple successes of Korzenik's seven-year-olds have taken only the earliest steps in accommodation to the audience. As the symbol-maker matures, as the messages he contrives become increasingly subtle and draw more and more on the accumulating depth of his experience, the problem of modeling the other with the self assumes new guises. The primary skill is to be able to read and respond sensitively to a message, but characteristically discriminative powers far outstrip productive powers. Certainly there are many concurrent explanations for good discriminators not automatically being good producers. But a factor that one would hope would be small seems large indeed: however discerning one may be about another's work, being discerning about one's own work demands a generous further measure of sophistication and technique.

LEARNING HOW: A FORBIDDING ENTERPRISE

Confronting directly the "how" of aesthetic endeavor, the studies summarized above illuminate indirectly the learning processes that lead a person to any given level of skill. They and like studies do this first in a conventional way, by transforming our concept of creative effort from a featureless mystery to an articulated interplay of component skills and phases of action. Ineffective performance can be attributed to particular lacks, learning and teaching construed in terms of particular skills and their coordination. But these studies can also illuminate the problem of learning through an unconventional question.

Surely the task of accomplishing a single work is a complex, demanding enterprise uncertain of success. Then how challenging a bootstrap enterprise is learning to perform just such tasks more effectively?

The paradoxical answer — or at least the hope — implicit in normal educational practice is that learning to do is easier than doing — it almost takes care of itself. Given feedback on the quality of output and some training in technical skills, the organism is imagined to converge regularly and inexorably toward skilled performance as long as effort continues, perhaps as a result of behaviorist “shaping” of procedures in response to the rewards of successful accomplishment.

But the suspicion looms that such complex behavior as was illustrated in the above studies simply does not optimize itself reliably. First there is the *reductio ad absurdum* argument that if it did, there would be many more superb artists and performers around than there are — certainly enough individuals are trying. Second, there are more explicit warnings. Ineffective strategies like the choir boy raising his chin may remain entrenched and unnoticed, despite extensive experience. Jones has identified other stubborn postural problems in the performing arts.²⁷ Some subjects in Gardner’s style discrimination study persisted with incorrect hypotheses in the face of random reinforcement. Certainly behavior normally improves — as with Korzenik’s subjects between the ages of five and seven — but just as certainly skill does not advance as rapidly, as directly, and (most critically) as *far* as one would like.

Such misgivings recommend exploring the opposite stance — what might make learning-to-do an order of magnitude more difficult than doing. The initial point must be that modification of procedure is a second-order variation necessarily taking place on a much slower time scale than modification of a work. One cannot be juggling one’s methods as often as one juggles tune blocks in Bamberger’s study or options in editing a poem, either consciously or unconsciously. After all, how well the latter juggles turn out is a major test of how well procedural alternatives succeed.

Second, earlier the evaluation of an ongoing work was characterized as the artist casting himself into the role of audience. He was presumably well equipped for such a role by a lifetime of incidental and finally deliberate attention to others’ and his own prior works. But no such training contributes to assessing one’s working procedures. Much of an expert’s work may be seen by the student, but little of his working.

Third, assessment of procedures, conscious or not, will be plagued by many of the same problems besetting assessment of ongoing works

one has produced — lack of distance, bias against finding flaws, and so forth. Also, such assessment, in depending on judging whether alternative procedures yield progress with the ongoing work, will inherit all the errors made in the evaluation of that work.

Furthermore, the space of alternative strategies is highly complex, the dimensions of possible variation numerous. The characterization of Mark's and Jorge's methods in the tune blocks investigation, the drastically revised procedure introduced in the poetry re-testing, and Beittel's identification of spontaneous and divergent approaches in painting²⁸ exemplify a few of probably many polar strategic options, and between the extremes lie innumerable gradations and hybrids. The cue of progress with the ongoing work is weak information for isolating effective strategies when overall procedures may differ from one another in so many ways.

Finally, effective learning often requires explicit attention to one's own procedures, as with the choir boy example. The deliberate conceptual mediation of change would seem particularly demanded when improvement requires a substantial and abrupt reorganization in behavior, rather than a smooth, incremental transition. But attention to such matters competes with the student's attention to his ongoing work, which is after all the primary interest. The usual consequence is that people think hardly at all about their own procedures.

In sum, if producing a single work is difficult and uncertain, learning how to produce more effectively is a challenge of another order entirely. Procedural options must be explored at a much slower pace. Progress on particular works is a crude and remote measure of strategic alternatives. The practices of the expert, which might provide a more direct standard, cannot generally be observed. And the work itself consumes all attention, including that crucial modicum of self-consciousness.

The first two of these four problems are inevitable, but the latter two are not. Apprenticeship as in a Renaissance studio offers the sort of close observation of the expert that can provide a direct standard for one's own behavior. Analysis of expert procedures can clarify and adapt them for student assimilation. Learning situations can be structured so that the student receives more, and more continuous, feedback, just as in Gardner's style training experiment students were given immediate signals of success, in Korzenik's study each new "jumping" picture was submitted to a guesser, or — to look outside the Project — as in Beittel's method artists observed films recording the evolution of a work they had produced.

Equipment and assignments can be organized to encourage a conscious confrontation with certain problems while setting others aside, as Bamberger's "tune blocks" game focuses on assembly of melodic fragments while avoiding concern with individual notes. Finally, explicit procedural instruction can tap abilities possessed but not exercised. Thus Howard would stress guiding the novice toward relatively simple principles of effective practice. Thus I was able to instruct poetry-editing subjects in a novel but readily adopted strategy. In all, there seems to be substantial opportunity to educate the student in procedure and to organize a learning situation leading him toward a greater critical consciousness of his own procedures.

The caution remains that the nature of any human ability is a study in itself, and a kind of study demanding its own style of thinking. Painting or composing or proving theorems is very different from *analyzing* painting or composing or theorem-proving. There is no messianic intent here to convert students into students of themselves. Just exactly how much a particular student can profitably think about his own practices is a most difficult question, although "hardly at all" seems both the usual trend and a very unlikely answer.

At the beginning of this essay, the reticent poet and his companions in uncertainty introduced two contrasting approaches to education for the arts. On the one hand, the teacher-artist could act as an exemplar and a critic; learning would depend on the student's imitation, and indeed on constructive rebellion. On the other hand, education could be based on an analysis of the processes and component skills underlying effective production of art. That these are not exclusive alternatives but complementary means toward the same end should now be clear.

An analysis of some fundamental problems in learning has led to recommending, among other things, much closer personal contact with practicing artists and their workaday efforts, even closer than the growing "artists in the schools" movement seems to achieve. Such contact, far from sidestepping supposedly destructive prying, encourages constructive observation by exposing for the student activities traditionally confined to the secluded garret or the study after midnight. From this perspective the student is as much an investigator as the scientist-educator. The personalized rapport of the one role and the systematic objectivity of the other obscure a common thrust: to observe, to learn from observation, and to derive from that learning means toward more effective performance.²⁹

Notes

1. Nelson Goodman, *Languages of Art* (Indianapolis: Bobbs-Merrill, 1968).
2. David Perkins, "Compensating for Distortion in Viewing Pictures Obliquely," *Perception and Psychophysics*, Vol. 14, No. 1 (1973), 13-18; David Perkins, "Visual Discrimination between Rectangular and Nonrectangular Parallelopipeds," *Perception and Psychophysics*, Vol. 12 (1972), 396-400; John Kennedy, "Perceived Lines Are Not Always the Sum of Their Contours," *Journal of Structural Learning*, Vol. 3, No. 4 (1972), 7-10; J. Kennedy, E. Mueller, and S. Tanimoto, "Inherent Perceptual Motivation and Discovery of Structure," *Journal of Structural Learning*, Vol. 3, No. 4 (1972), 1-6; Howard Gardner, "Children's Sensitivity to Painting Styles," *Child Development*, Vol. 41, No. 3 (September 1970), 813-821; Howard Gardner, "Style Sensitivity in Children," *Human Development*, Vol. 15, No. 6 (1972), 325-33; Howard Gardner, "The Development of Sensitivity to Figural and Stylistic Aspects of Paintings," *British Journal of Psychology*, Vol. 63 (1972), 605-15; Howard Gardner, "The Contribution of Operativity to Naming in Aphasic Patients," *Neuropsychologica*, Vol. 11 (1973), 213-20; Howard Gardner, "The Naming and Recognition of Written Symbols in Aphasic and Alexic Patients," *Journal of Communication Disorders* (1974, in press); Vernon Howard, "On Musical Expression," *British Journal of Aesthetics*, Vol. 11, No. 3 (Summer 1971), 268-80; Vernon Howard, "On Representational Music," *Nous*, Vol. 6, No. 1 (1972), 41-53; David Perkins, "Coding Position in a Sequence by Rhythmic Grouping," *Memory and Cognition* (1974, in press); Jeanne Bamberger, "Learning to Think Musically," *Music Educator's Journal*, Vol. 59, No. 7 (March, 1973), 53-57; Paul Kolars, "Some Formal Characteristics of Pictograms," *American Scientist*, Vol. 57, No. 3 (May-June 1969), 348-63; Paul Kolars, "Some Psychological Aspects of Pattern Recognition," in P. Kolars and M. Eden, eds., *Recognizing Patterns* (Cambridge: MIT Press, 1968); Paul Kolars, "The Role of Shape and Geometry in Picture Recognition," *Picture Processing and Psychopictorics* (New York: Academic Press, 1970), pp. 179-202; Paul Kolars and David Perkins, Orientation of Letters and Errors in Their Recognition," *Perception and Psychophysics*, Vol. 5 (May 1969), 265-69; Paul Kolars and David Perkins, "Orientation of Letters and Their Speed of Recognition," *Perception and Psychophysics*, Vol. 5 (May 1969), 275-80; Frank Dent, "The Lecture-Performance: An Instrument for Audience Education," *Harvard Project Zero, Technical Report No. 7*, September 1972; Frank Dent, "Zeroing in on Art," *Harvard Bulletin*, Vol. 73, No. 11 (May 1971), 41-44; Barbara Leondar, "The Arts in Alternative Schools: Some Observations," *Journal of Aesthetic Education*, Vol. 5, No. 1 (January 1971), 75-92; Barbara Leondar, "English in Experimental Schools," *English Journal*, Vol. 60, No. 6 (September 1971), 743-58; Barbara Leondar, "Metaphor in the Classroom," in Ralph Smith, ed., *Aesthetic Concepts and Education* (Urbana: University of Illinois Press, 1970), pp. 366-90.
3. Howard Gardner, *The Arts and Human Development* (New York: Wiley, 1973); John Kennedy, *Images and Information* (San Francisco: Jossey Bass, 1974); Paul Kolars, *Aspects of Motion Perception* (Toronto: Pergamon Press, 1972).

4. Vernon Howard, "Harvard Project Zero: A Fresh Look at Art Education," *Journal of Aesthetic Education*, Vol. 5 (January 1971), 61-74; Vernon Howard, "Art, Symbolism, and Education," *Bulletin of the Council for Research in Music Education*, No. 30 (Fall 1972), 1-10.

5. Nelson Goodman, David Perkins, and Howard Gardner, "Basic Abilities Required for Understanding and Creation in the Arts," *Final Report for the U.S. Office of Education*, Harvard Project Zero (1972) and ERIC microfiche ED 071 989.

6. Howard Gardner, Vernon Howard, and David Perkins, "Symbol Systems: A Philosophical, Psychological and Educational Investigation," *National Society for the Study of Education 1974 Yearbook* (in press).

7. A. Newell and H. Simon, *Human Problem Solving* (Englewood Cliffs, N.J.: Prentice-Hall, 1972).

8. J. Bruner, J. Goodnow, and G. Austin, *A Study of Thinking* (New York: Wiley, 1956).

9. J. Piaget, "Piaget's Theory," in P. Mussen, ed., *Carmichael's Manual of Child Psychology* (New York: Wiley, 1970), Vol. 1, pp. 703-32.

10. R. Olton and R. Crutchfield, eds., "Developing the Skills of Productive Thinking," in G. Davis and S. Joseph, *Training Creative Thinking* (New York: Holt, Rinehart and Winston, 1971), pp. 238-60.

11. W. Feurzeig, S. Papert, M. Bloom, R. Grant, and C. Solomon, "Programming Languages as a Conceptual Framework for Teaching Mathematics," *Technical Report #1889* (Cambridge, Mass.: Bolt, Beranek, and Newman, 1969).

12. E. Torrance, "Can We Teach Children to Think Creatively?" *Journal of Creative Behavior*, Vol. 6 (Second Quarter 1972), 114-43.

13. Of course we are not entirely alone in taking a process approach. Notable are Patrick's early process-tracing studies of poetry writing and drawing (C. Patrick, "Creative Thought in Artists," *Journal of Psychology*, Vol. 4 [1937], 35-73, and "Creative Thoughts in Poets," in R. Woodworth, ed., *Archives of Psychology*, No. 178 [1935], 5-74) and Beittel's studies of painting using time-lapse photography (*Mind and Context in the Art of Drawing*, [New York: Holt, Rinehart and Winston, 1972]).

14. Several of the studies reviewed below, as well as research by other Project members, will be treated in depth in a collection of articles to be called *The Arts and Cognition*, now in preparation.

15. C. Patrick, "Creative Thought in Poets," in R. Woodworth, ed., *Archives of Psychology*, No. 178 (April 1935), 5-74.

16. R. M. Gagne and E. C. Smith, "A Study of the Effects of Verbalization on Problem Solving," *Journal of Experimental Psychology*, Vol. 63 (January 1962), 12-18.

17. M. Wallach, "Creativity," in P. Mussen, ed., *Carmichael's Manual of Child Psychology* (New York: Wiley, 1970), Vol. 1, pp. 1211-72.

18. This effort is a part of the "LOGO" Project at MIT's Artificial Intelligence Laboratory. See Jeanne Bamberger, "Learning to Think Musically," *Music Educator's Journal*, Vol. 59, No. 7 (March 1973), 53-57.

19. Howard Gardner, "Children's Sensitivity to Painting Styles," *Child Development*, Vol. 41 (1970), 813-21; Howard Gardner and Judith Gardner,

"Developmental Trends in Sensitivity to Painting Styles and Subject Matter," *Studies in Art Education*, Vol. 12 (Fall 1970), 50-56.

20. Howard Gardner, "The Development of Sensitivity to Figural and Stylistic Aspects of Paintings," *Harvard Project Zero, Technical Report No. 3* (1971).

21. R. J. Herrnstein, "Superstition: A Corollary of the Principles of Operant Conditioning," in Werner K. Honig, ed., *Operant Behavior: Areas of Research and Application* (New York: Appleton-Century-Crofts, 1966), pp. 33-51.

22. J. Bruner, J. Goodnow, and G. Austin, *A Study of Thinking* (New York: Wiley, 1956).

23. Vernon Howard, "On Musical Expression," *British Journal of Aesthetics*, Vol. 11, No. 3 (January 1971), 268-80; Vernon Howard, "On Representational Music," *Nous*, Vol. 6, No. 1 (1972), 41-53.

24. John Kennedy, "Infants' Finger-Painting Strategies," in N. Goodman, D. Perkins, and H. Gardner, "Basic Abilities Required for Understanding and Creation in the Arts," *Final Report for the U.S. Office of Education*, Harvard Project Zero (1972), 48-49, and ERIC microfiche ED 071 989.

25. Diana Korzenik, "Children's Drawings: Changes in Representation between Ages 5 and 7," Ph.D. dissertation, Harvard University, 1972.

26. Paul Kolars, "Three Stages of Reading," in H. Levin and J. Williams, eds., *Basic Studies on Reading* (New York: Harper and Row, 1970).

27. Frank Jones, *A Technique for Musicians* (London: Sheildrake Press, 1968); Frank Jones, "Voice Production as a Function of Head Balance in Singers," *Journal of Psychology*, Vol. 82 (May 1972), 209-15.

28. Kenneth Beittel, *Mind and Context in the Art of Drawing* (New York: Holt, Rinehart and Winston, 1972).

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